Design of Control and Monitoring System to Avoid Inter-Ship Collisions in West Shipping Lane Tanjung Perak Surabaya

Devina P. Sari [1], Aulia S. Aisyah[1], and A. A. Masroeri[2]

Abstract*—The occurrence of several ship accidents in narrow waters of Madura strait which is the west shipping lane of Tanjung Perak Surabaya has inspired the research on the design of a control system on the ship to avoid any collision between ships. The existence of automatic control with the autopilot is required to minimize the occurrence of collisions between ships In this final study investigated the application of fuzzy logic to control the yaw angle on the vessel MV Karana Sembilan. Fuzzy logic used is Sugeno Takagi type with the input of the error yaw, yaw rate and distance of the ship with a disturbance. Tests conducted with a control system without disturbance, with disturbance, and the presence of obstacles in front of the ship. Performance of control system is obtained by using the disturbance, the fuzzy appearance is 2:41 hm distance position, the speed of 7.5 knots and 0.5 error, then the resulting yaw angle is 6580. Results control with fuzzy syncronized with monitoring at M&C system in visual basic. The view of the monitoring, 3 types of scenarios obtained. For the first scenario, which is created with the control on it, produces the best results of the avoidance, if compared to the second scenario, with trajectory and control anti-collision cross, and if compared with the third scenario that has no built control system with decision-making on it.

Keywords—***Fuzzy Logic Control, Ship, Control System, M&C Systems and vessel obstruction***

Abstract*—Terjadinya beberapa kecelakaan kapal di alur barat pelayaran Tanjung Perak Surabaya melatarbelakangi sebuah penelitian tentang perancangan sistem kendali pada kapal untuk menghindari adanya tabrakan antar kapal. Adanya pengendalian otomatis secara autopilot diperlukan untuk meminimalisir terjadinya tabrakan antar kapal. Dalam penelitian ini menyelidiki penerapan logika fuzzy untuk mengendalikan sudut yaw atau sudut belok kapal pada kapal MV Karana Sembilan.Logika Fuzzy yang digunakan adalah tipe Sugeno Takagi dengan masukan berupa eror yaw, laju yaw dan jarak kapal dengan halangan. Pengujian dilakukan dengan system kendali tanpa gangguan dengan gangguan dan dengan adanya halangan kapal di depannya Sistem pengendalian menggunakan kontrol fuzzy didapatkan nilai saat penghalang berada pada posisi 313 meter, kecepatan 15 knot dan error heading kapal 0.645 maka sudut yaw 23.9 derajat dan untuk penghalang berada pada posisi 1000 meter, kecepatan 15 knot dan error heading kapal 0.572 maka sudut yaw 15 derajat. Hasil pengendalian dengan fuzzy di sinergikan dengan monitoring pada system M&C di visual basic. Simulasi monitoring yang dilakukan ialah M&C penelitan sebelumnya dengan builder data baru yang disesuaikan dengan kondisi real di tanjung perak. Diberikan 3 skenario didalamnya yaitu Skenario pertama dan kedua sama-sama diberikan pengendalian dengan fuzzy sedangkan untuk skenario 3 tidak diberikan. Didapatkan hasil belokan lebih smooth serta mampu menghindari halangan untuk skenario1 dan 2.

Kata kunci—***Kontrol Logika Fuzzy, Kapal, Sistem Pengendalian, Sistem M&C dan halangan kapal***

I. INTRODUCTION

1.1 Background

Islands Indonesia is a country that has the water sector is 2/3 of the whole area of Indonesia, making Indonesia also referred to as a maritime country. Currently, Commerce uses sea transport industry has been growing rapidly, where it is due to an increase of commodity exports - imports as well as the density of ship traffic significantly. Because it - it is, it is necessary to the security of a ship to control the collision and can monitor the strategic location of the vessel to facilitate monitoring of vessels.

This research will be done design control and design of the monitoring system of maritime transport in the groove cruise west Surabaya Tanjung Perak (Karang jamuang - Tanjung Perak) with the rules of fuzzy logic based intelligent control.

1.2 Problems

Issues raised for this study is how to design control systems using fuzzy logic control and mengsinergikannya with the development of M & C systems are made so as to obtain the corresponding performance results and is able to minimize the impact on the ship.

1.3 Limitations

Limitation problem in the study were:

1. Ship used in this study is that the ship cargo ship MV. Karana Sembilan.
2. Control and monitoring system designed to know the position, direction and trajectory of the ship

[1] Devina P. Sari and Aulia S. Aisyah are with Department of Physics Engineering, Institut Teknologi Sepuluh Nopember, 60111, Surabaya, Indonesia. Email: d3vina_songhyekyo@yahoo.com.

[2] A. A. Masroeri is with Department of Ship Design Engineering, Institut Teknologi Sepuluh Nopember, 60111, Surabaya, Indonesia.

3. Interference with the dynamics of the ship at the port of Tanjung silver adapted to real conditions of the ocean currents
4. Rudder is a type of van used amorengen.
5. Control system design method based on fuzzy logic control.
6. The controlled variable is the ship *yaw* angle.
7. The tools simulate the control system for monitoring, while Matlab is R2009a software Visual Basic 6.0

1.4 Purpose

The purpose of the study is to design control systems using fuzzy logic control system development and mengsinergikan with M & C is made so as to obtain the corresponding performance results and is able to reduce the collision rate on the ship.

II. METHOD

Study of literature and data retrieval b erupa understanding theoretically and geographical zones of the western waters of Tanjung Perak Surabaya line up on the island karangjamuang, include grooves or tracks real cruise, the current speed as an object of real problems that exist in the port of Tanjung Perak Surabaya, buoy point, the specification 4 commercial vessel (MV Karana Sembilan, Ocean Goddess XV KM, MV Sinar Bintan, Sinar Jambi) obtained from the ship on a particular PT. Pelindo III to be used in modeling the dynamics of the ship, data AIS *(Automatic Identification System)* of the Navigation District VTS class I.

Simulation of control to avoid collisions is obtained from modeling with the MV Karana Sembilan specifications hydrodynamic coefficients are generated from the physical specifications of the ship is owned by the length (L) = 96 m, width (B) = 5.18 m, depth (T) = 7.5 m, the block coefficient (CB) = 0.7077, maximum speed = 14.72 knots, *Xenter of Grafity* XG = 6.2 m, and*displacement* / mass Δ = 9662.8 tons. Sec = 2552.53tons. *Rudder* is the type of van used amorengen. Data of this specification, are used as inputs in the form of crisp determinant distance (via radar), *yaw* angle *error,* and *yawrate.*

As for the monitoring system developed by M & C system before, made a real data situation dipelabuhan Tanjung Perak in Surabaya to eventually be able to synergize with the data in the control simulation.

The transfer function for *cargo* ships (calculation attached) is,

$$\frac{\varphi}{\delta} = \frac{2{,}44103939 + 19{,}5943089s}{s + 15{,}9891329s^2 + 19{,}8635477s^3}$$

$$\frac{r}{\delta} = \frac{2{,}44103939 + 19{,}5943089\mathrm{s}}{1 + 15{,}9891329s + 19{,}8635477s^2}$$

As for the transfer function of the current noise of the waves obtained from equation above. Flow velocity in the port of Tanjung Perak on December 9, 2010 obtained V max = 0.20 m / s and V min = 0.15 m / s. So we get the transfer function equation for the wave disturbance is:

$$V_c(0) = 0.5\,(V_{max} + V_{min})$$
$$V_c(0) = 0.5\,(0.25 + 0.15)$$
$$V_c(0) = 0.20$$
$$\frac{dVc(t)}{dt} + \mu 0 Vc(t) = \omega(t) \qquad (2.1)$$

For Rudder where attached to the ship's cargo ships are the type of Van Amorengen, serves as a driver or actuator control systems. It has ability to work with a range of-35 º to 35 º and the rate of employment between the rudder-2.33 º to 7 º.

Manuvering control system to avoid collisions on the cargo ship MV Karana Sembilan is based on fuzzy logic. Control system block diagram of manuvering to avoid a collision can be seen in Figure 1.Function of radar is the same as the sensor, ie, to detect obstacles in front of him, for example vessels or foreign objects do not move, the distance that varies according to the working ability of the radar.

III. RESULT AND DISCUSION

3.1 Design of Fuzzy Logic Based Control Systems

Design of fuzzy logic controllers through FIS (Fuzzy Inference System) editor with a fuzzy logic controller input error value heading (error *), and the distance barrier yawrate (d) are measured by radar, and outputs a control action y, which gives a signal to the rudder. Methods of decision making in this study using the inference method (Sugeno) rules that the use of the operating rules of Sugeno, and defuzzifikasi SUM or sum. In Figure 2 is shown a flow diagram of fuzzy logic controllers.

3.2 Design of Simulation

In this study created a monitoring scenario, which contains:

1. The first scenario

In the first scenario figure 7, monitoring built in visual basic is to use fuzzy algorithms of data that has been built with the control anti obstruction or anti collision, so that, looking at the picture that is the avoidance of the bow of the ship in the ship MV depannya.tampak Karana Sembilan (below) are smooth turning action, as well as for the ship MV Sinar Bintan (above) also take action to turn. The figure 8, for the ship KM Dewi Samudra XV (left), is conducting a smooth turn on action. And also to ship Sinar Jambi. Path in the first scenario is consistent with the actual trajectory at KLF have been made.

In the second scenario was created trajectory purpose of the ship MV Karana Sembilan leading to a second destination is Karang jamuang, while for the ship KM Dewi Samudra XV is the leading destination port or port 7 Kamal, so the path is a path trodden by crosses. There are also anti-barrier control or anti-collision. This figure 10, that the ship MV Karana Sembilan (below) that turn smooth action, and followed by KM Dewi Samudra XV (above) is also a smooth turning action.

2. Third scenario

In the third scenario constructed by crossing trajectories, ie trajectories purpose of the ship MV Karana Sembilan headed to a destination is Tanjung Perak Surabaya, while for the ship KM Dewi Samudra XV is the destination port or Kamal port. On the other hand in the third scenario is not given the anti-collision control, so as to effect the MV Karana Sembilan (above) and the ships collide KM Dewi Samudra XV, and for the monitored results of the action and a warning is not appropriate.

IV. CONCLUSION

Based on research that has been done, the conclusion as follows:

1. Sembilan cargo ship MV Karana in open loop condition is not capable of doing when given the input control action to take action to turn (turning).
2. In getting the flow path and the silver cape Karang jamuang is a navigation system adapted to the buoy that is located between the red and green buoys.
3. In the simulation found that the fuzzy controller is able to take action control in accordance with a set point in the form of the heading angle.
4. Control system using fuzzy control value obtained when the barrier is at 313 meter position, speed 15 knots and the ship heading error 0. 645 the yaw angle to 23.9 degrees and the barrier is at position 1000 meters, speed 15 knots and the ship heading error 0. 572 the yaw angle of 15 degrees.
5. Monitoring conducted simulation is M & C research with the builder before new data are adjusted to the real conditions in a silver cape. Given three scenarios in it. The first and second scenarios are equally given to the fuzzy control, while for scenario 3 is not given. Smoother curves obtained results and to be able to avoid obstacles to skenario1 and 2.

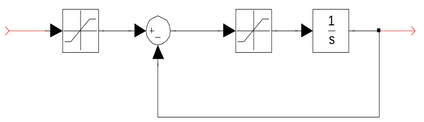

Figure 1. *Rudder* Van Amorengen

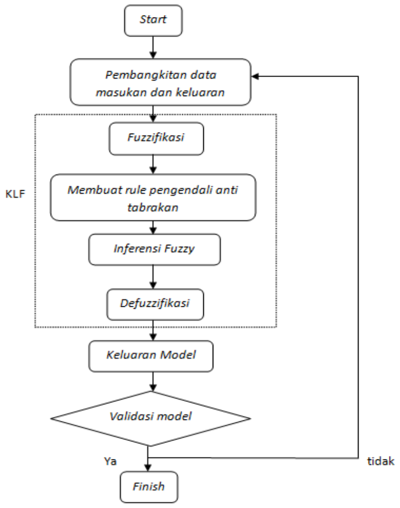

Figure 2. Flowchart y Fuzz Logic Controller

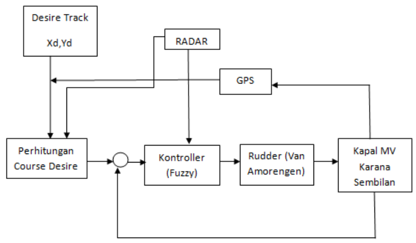

Figure 3. Control Block Diagram

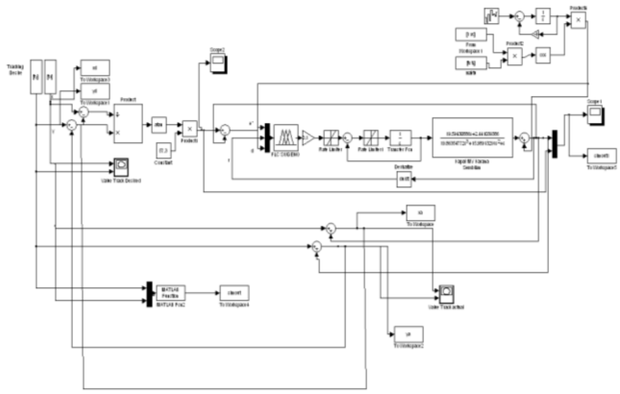

Figure 4. Simulink Control System with No Disturbance

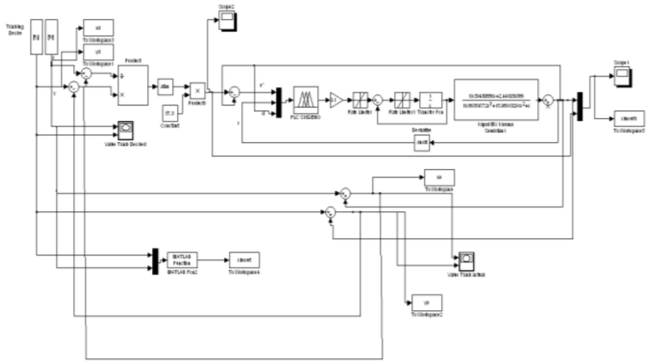

Figure 5. *Simulink* control system with moving obstacles

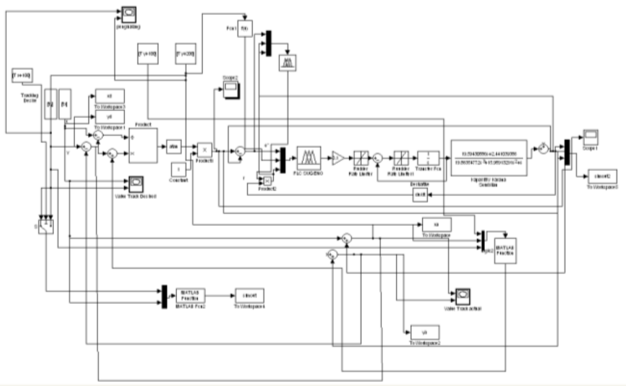

Figure 6. *Simulink* control system with moving obstacles

Figure 7. Simulation of the first scenario to 9.07 seconds

Figure 8. The first scenario simulated seconds to 12.38

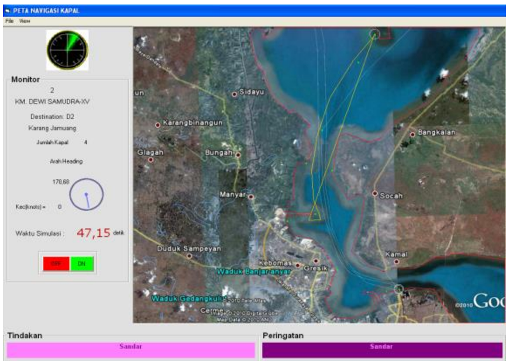

Figure 9. Simulation time has been docked all vessels in 47.15 seconds

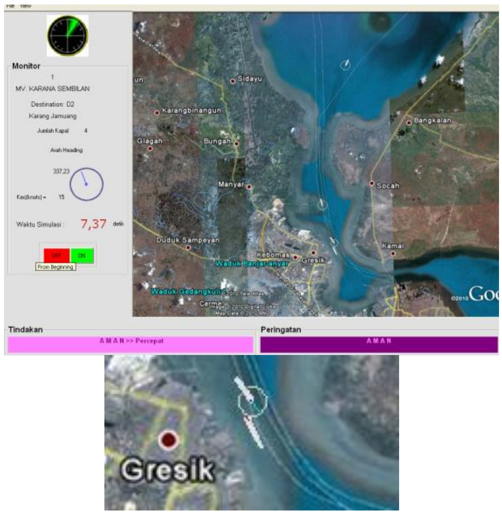

Figure 10. Simulation of the second scenario 7, 37

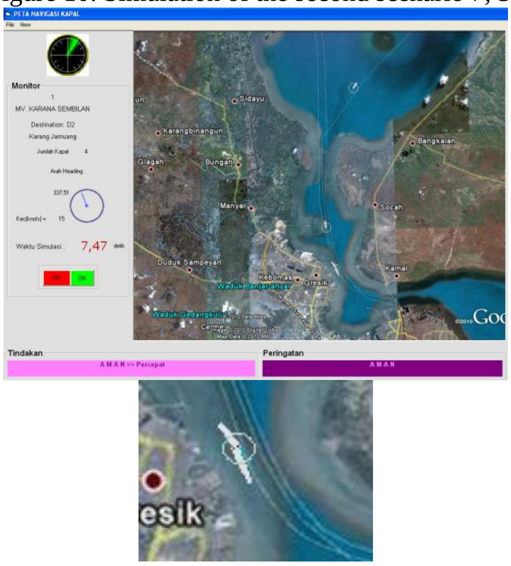

Figure 11. Simulation of a third scenario in 7.47 seconds

REFERENCE

[1] S. A, Aulia. "Development of Monitoring Systems and Intelligent Control for Improving Quality in Ship Management Marine transportation", 2010.
[2] R. Anitasari, "Maneuver Control system design for Avoiding Collisions at Fuzzy Logic-based Ship Tank". Dpartment of f Engineering Physics, FTI-ITS Surabaya, 2010.
[3] E. Aris."Design Direction and Speed Full Automatic Line Sailing Ships at Karang jamuang - Tanjung Perak-Based Fuzzy Logic for Improving Transportation Sea". Engineering Physics FTI ITS Surabaya, 2010.
[4] R. H. Arif, "System Design Flow Monitoring On Cruise Ship Port of Tanjung Perak Surabaya". Engineering Physics FTI ITS Surabaya, 2010
[5] A. A. Masroeri. "Development of DSS (Decision Support System) Based on AIS Data for Improving the Safety of Ship Operation in Tanjung Perak Port Surabaya", 2010.
[6] T. I. Fossen, , "Guidance and control of ocean vehicles", John Willy & Son, 1994.